

# **User Manual for GeoJModelBuilder**

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## 1. About GeoJModelBuilder

### 1.1 Introduction

GeoJModelBuilder is an open-source (released under the GNU General Public License version 2) model builder tool that couples geospatial Web services, NASA World Wind and Sensor Web to support geoprocessing modeling and environmental monitoring.

The tool can allow users to drag and drop various geospatial services to visually generate workflows and interact with the workflows in a virtual globe environment. It also allows users to audit trails of workflow executions, check the provenance of data products, and support scientific reproducibility.

### 1.2 Copyright information

Copyright (C) 2013

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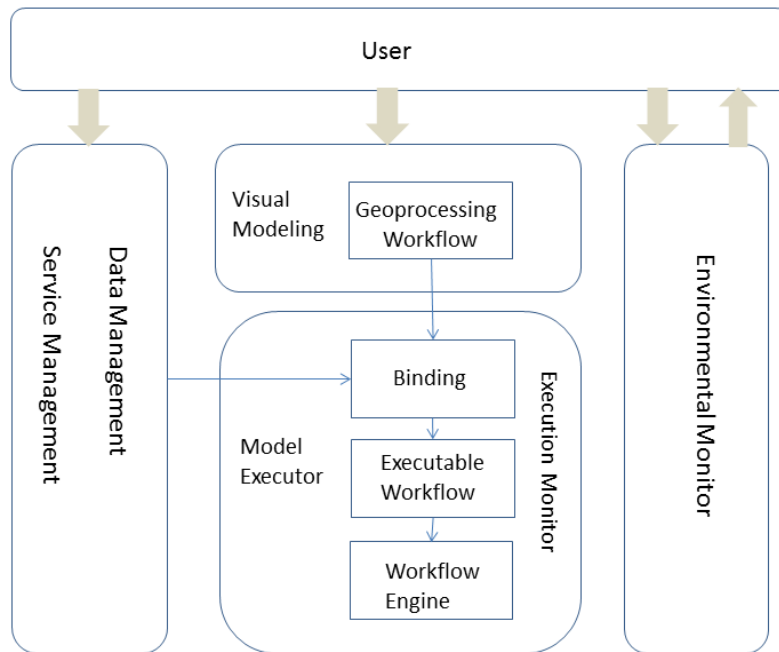
### 1.3 License Agreement

This program is free software. You can redistribute and/or modify it under the terms of the GNU General Public License version 2 as published by the Free Software Foundation. Free Software Foundation web page, <http://www.fsf.org>.

This program is distributed without any warranty; even without the implied warranty of merchantability or fitness for a particular purpose. See the GNU General Public License for more details. <http://www.gnu.org/licenses/gpl-2.0.html>

## 2. Architecture

GeoJModelBuilder contains four modules:

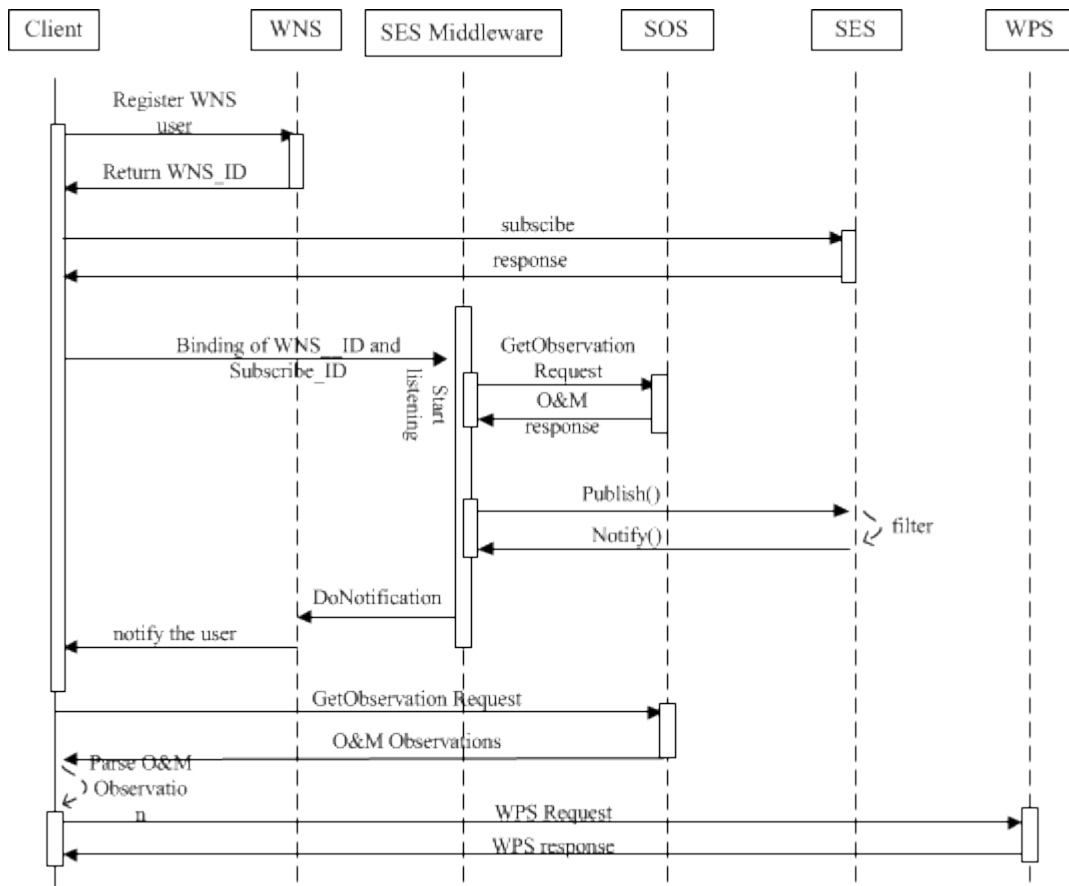


**Fig. 2.1** Architecture for the management of a workflow

- (1) Geoprocessing Workflow Designer: A scientific workflow can be visually generated by dragging and dropping various geospatial services. The implementation follows the Model-View-Control pattern. Graphics are stored separately with models. This tool separates geoprocessing workflow from the Web service and data which is flexible in that we can choose alternative services or data when the workflow is executed.
- (2) Model Executor: A workflow execution engine is implemented to transform a geoprocessing workflow into an executable workflow, monitor the status of execution and record the provenance.
- (3) Service and data management: This module's functionality is to manage services and data. OGC-Standard services, such as Web Processing Service (WPS), Web Feature Service (WFS), Sensor Observation Service (SOS) can be managed as

fundamental tools to construct workflows. NASA World Wind is available for the visualization of sensors, input data and results.

(4) Environmental Monitor: Sensor Web services such as SOS, SES and WNS are used in environmental monitoring. A middleware named SES Middleware is proposed to integrate SOS, SES, WNS and WPS. They are responsible for observations, user subscription, user notification and data processing. The architecture is shown as Fig. 2.2.



**Fig. 2.2** Environmental monitoring architecture

### 3. Installation

The programming language used for the development is Java due to its platform-independent feature. The source codes can be operated on any operating systems such as Windows or Unix/Linux that supports Java.

Nowadays, we provide a window installer. When using this installer, requirements and installation procedure are as following:

Requirements:

Windows XP or higher (tested with Windows 7).

Installation procedure:

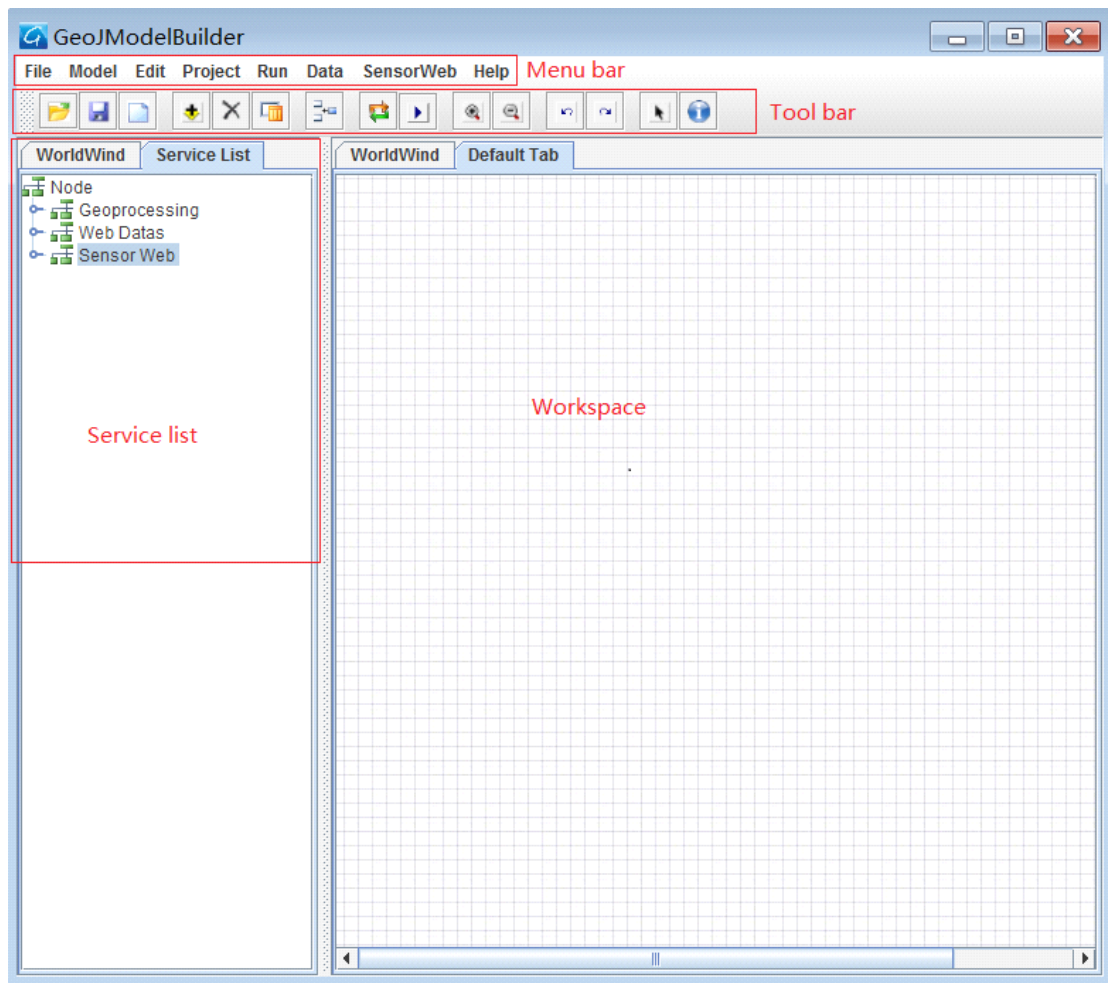
a) Download GeoJModelBuilder.exe from

<https://sourceforge.net/projects/geopw/files/>

b) Follow the installation instructions. It is easy to finish the installation step by step.

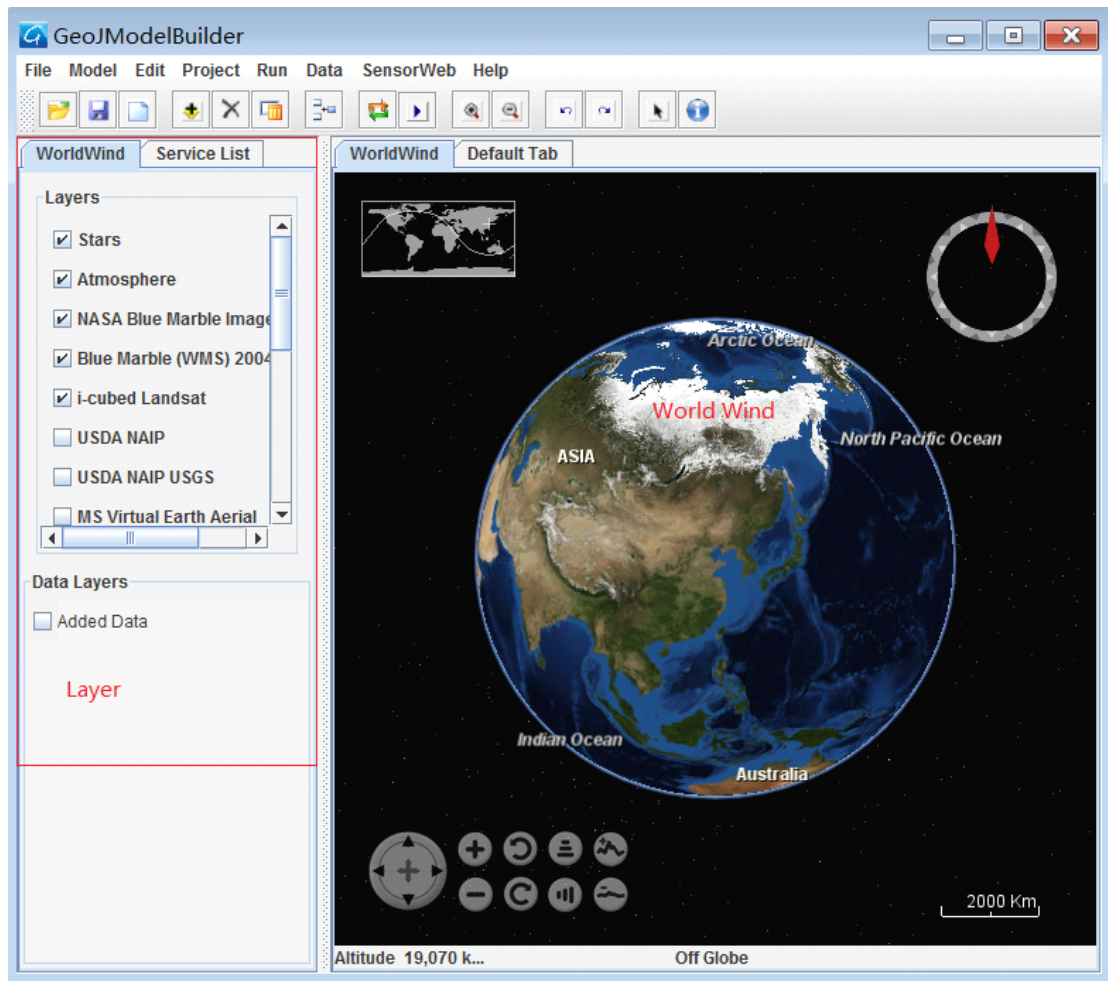
## 4. Introduction

### 4.1 User Interfaces



**Fig. 4.1** User interface





Users drag geoprocessing service from the service list and drop it into the workspace and then a graphic element will appear in the panel.



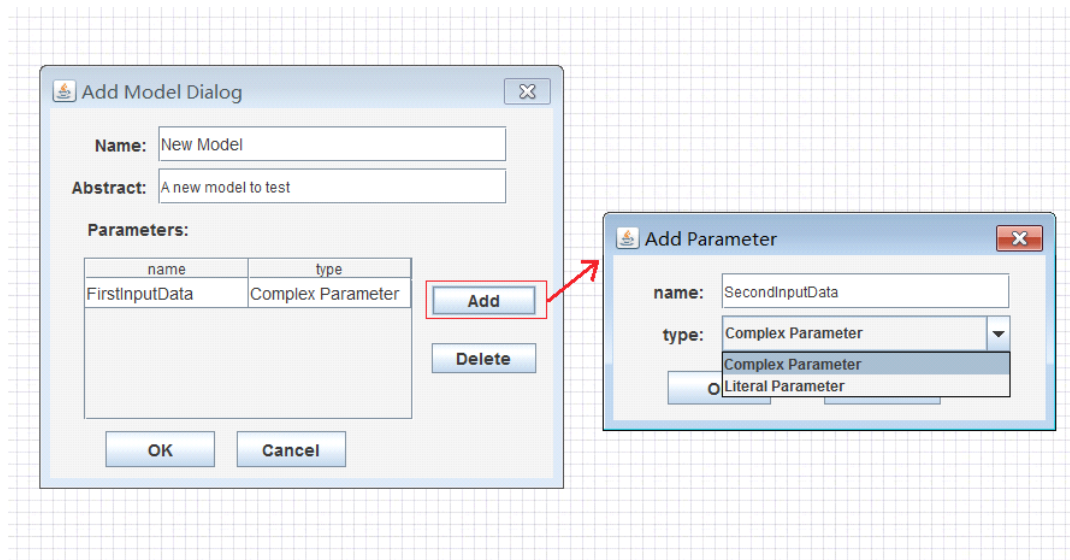
**Fig. 4.2** User interface

As shown in Fig.4.2, World Wind is integrated into GeoJModelBuilder as one part.

## 4.2 Basic Operations

- (1)  Open: Open the model file and add to the current workspace.
- (2)  Save: Save the models in the workspace to a file.
- (3)  New: Create a new workspace.
- (4)  Add a Model: Add a new model into the current workspace.





**Fig. 4.3** Add a model

Name: The name of the model.


Abstract: Summary description of the model.


Parameters: Parameters contained in the model. Two different kinds of parameters are provided here.


a) Complex Parameter: Equivalent to the “ComplexData” in OGC WPS specification. “ComplexData” (such as XML or imagery), is one of the following allowable combinations of format (mimetype, encoding, and schema). The value of this complex data structure can be (either) directly encoded in the Execute operation request or made available through a web accessible URL.

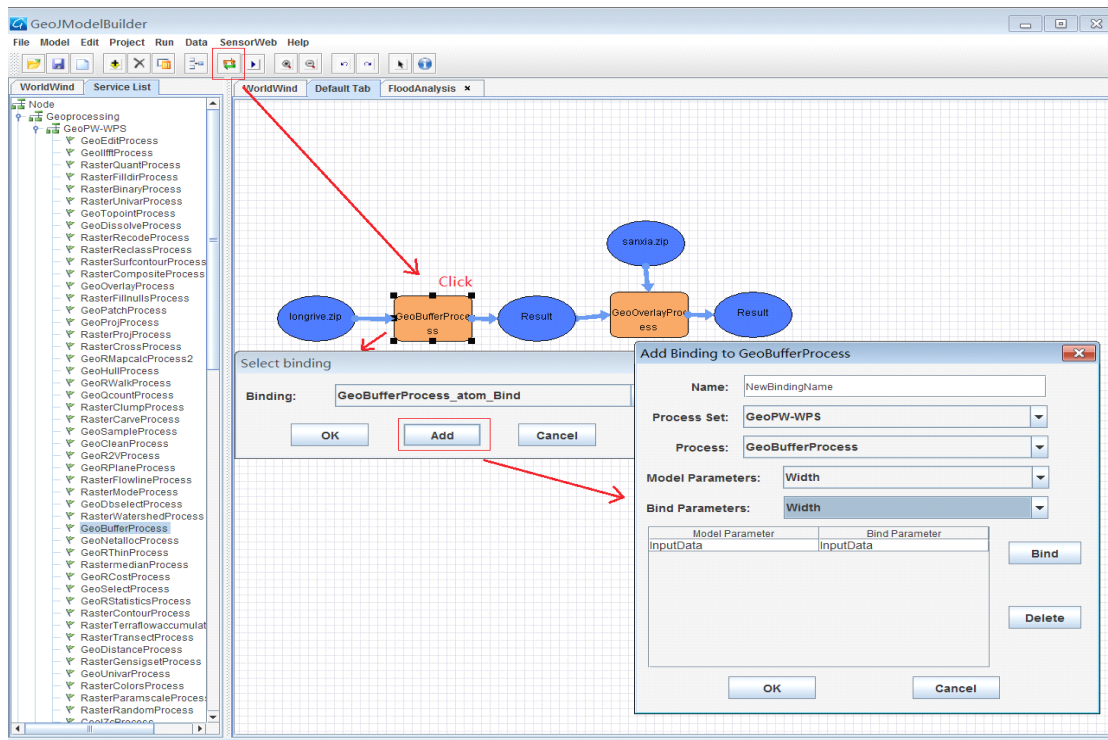
b) Literal Parameter: Equivalent to the “LiteralData” in OGC WPS specification. “LiteralData” with a specified data type, allowable values, default value, and allowable unit of measure indicated.

(5)  Delete: Delete the selected models in the current workspace.

(6)  Clear: Clear all the models in the current workspace.


(7)  Add Flow: Create a control flow. Click on the result of prior model, drag the mouse to another model, and then select the binding parameter information after releasing the mouse.

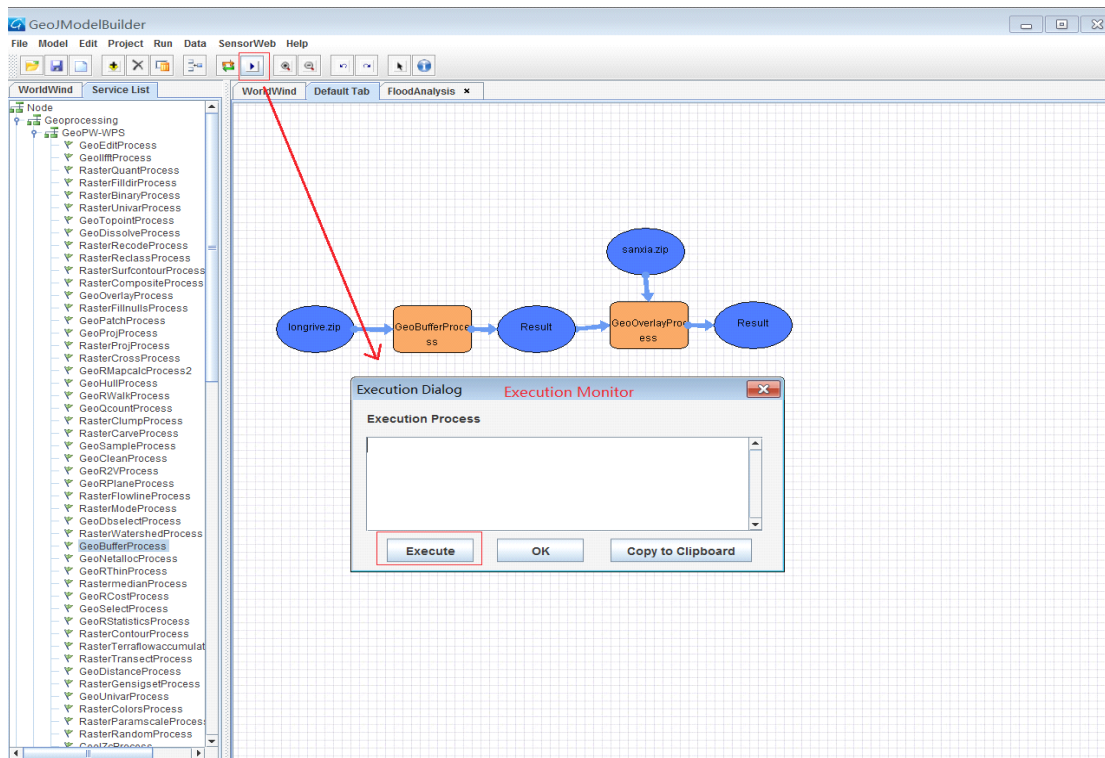
(8)  Binding: Bind the model with a certain geoprocessing service before the execution of the workflow.









**Fig. 4.4** Service binding

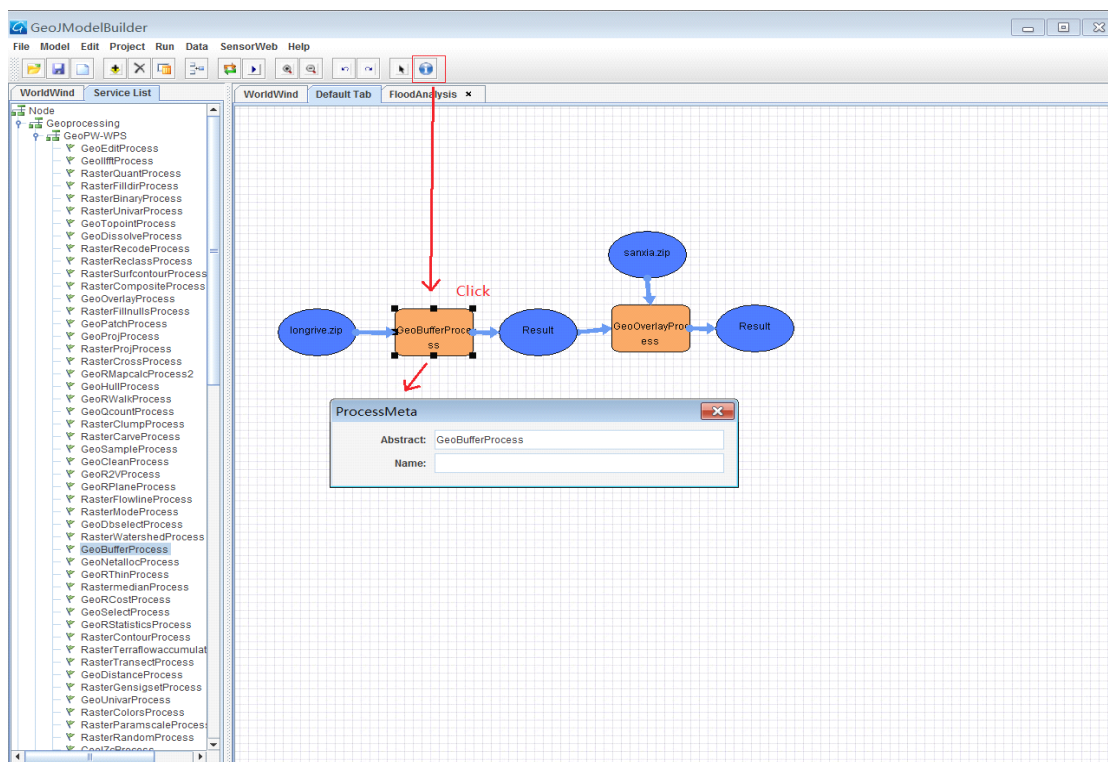
In the binding dialog, user can bind parameters one by one.

- (9)  Run: Run the workflow in the current workspace.



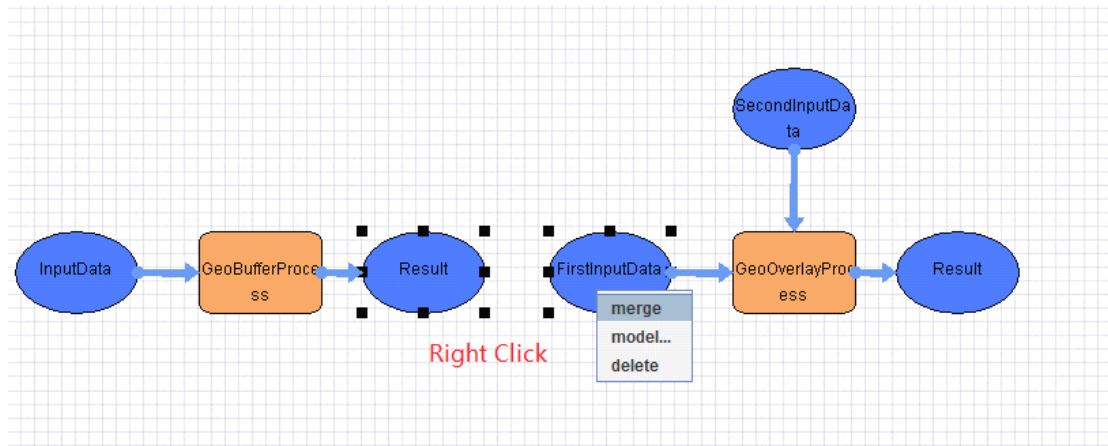
**Fig. 4.5** Execute the workflow

- (10)  Zoom In: Zoom in the graphics in the current workspace.
- (11)  Zoom Out: Zoom out the graphics in the current workspace.
- (12)  Undo: Undo the last operation.
- (13)  Redo: Redo the operation.
- (14)  Select: Select graphics. Multiple selection is supported when ctrl key is pressed.
- (15)  Detail: Click on the graphic, user can get the detail information of the model or data.



**Fig. 4.6** Detail information

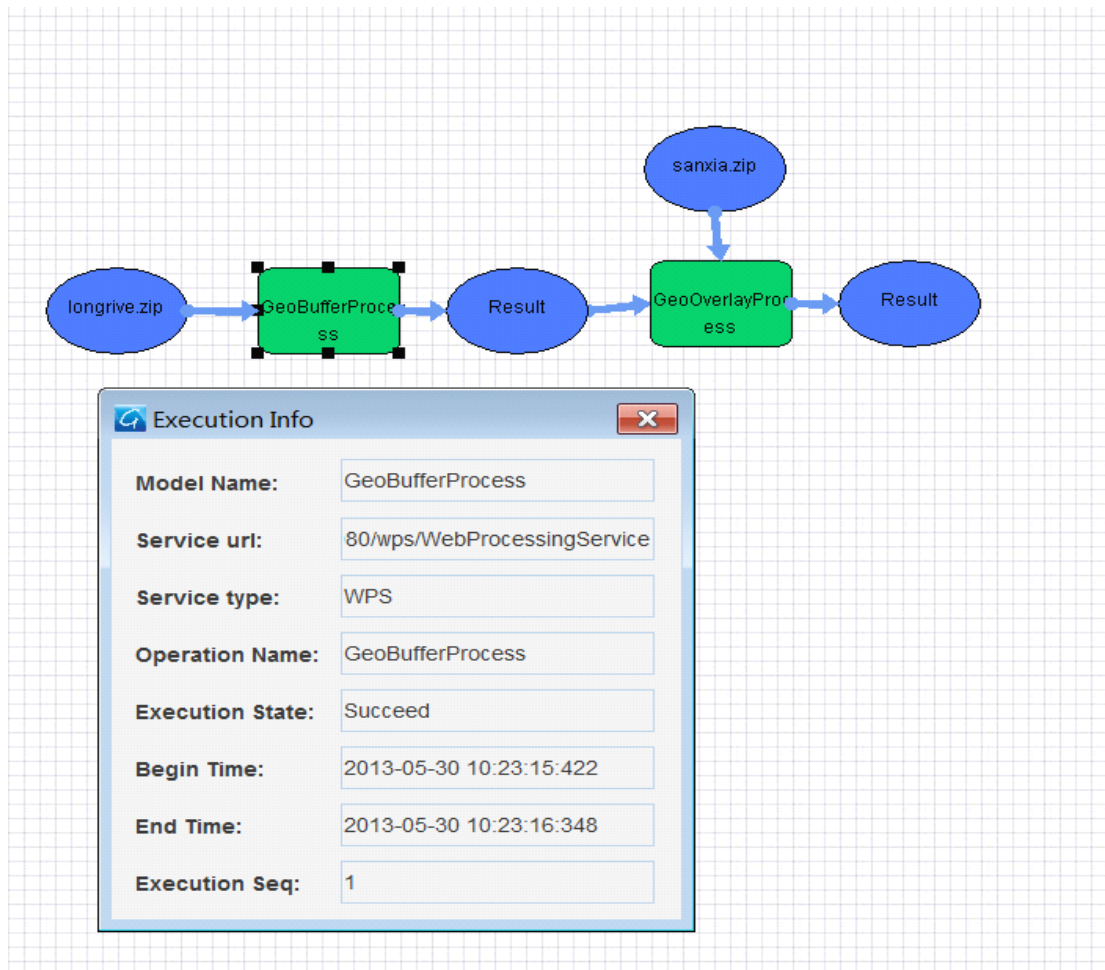
- (16) Merge: Merge the result of the prior model and the input data of the latter model. User can use this operation to create a control flow, too.



**Fig. 4.7** Merge

(17) Export Image: “File ----> Export Image...”, export the scientific workflow in the current workspace as an image.

(18) Run Information: “Run ---> Run Information”, view the detail information of workflow execution.



**Fig. 4.8** Running information

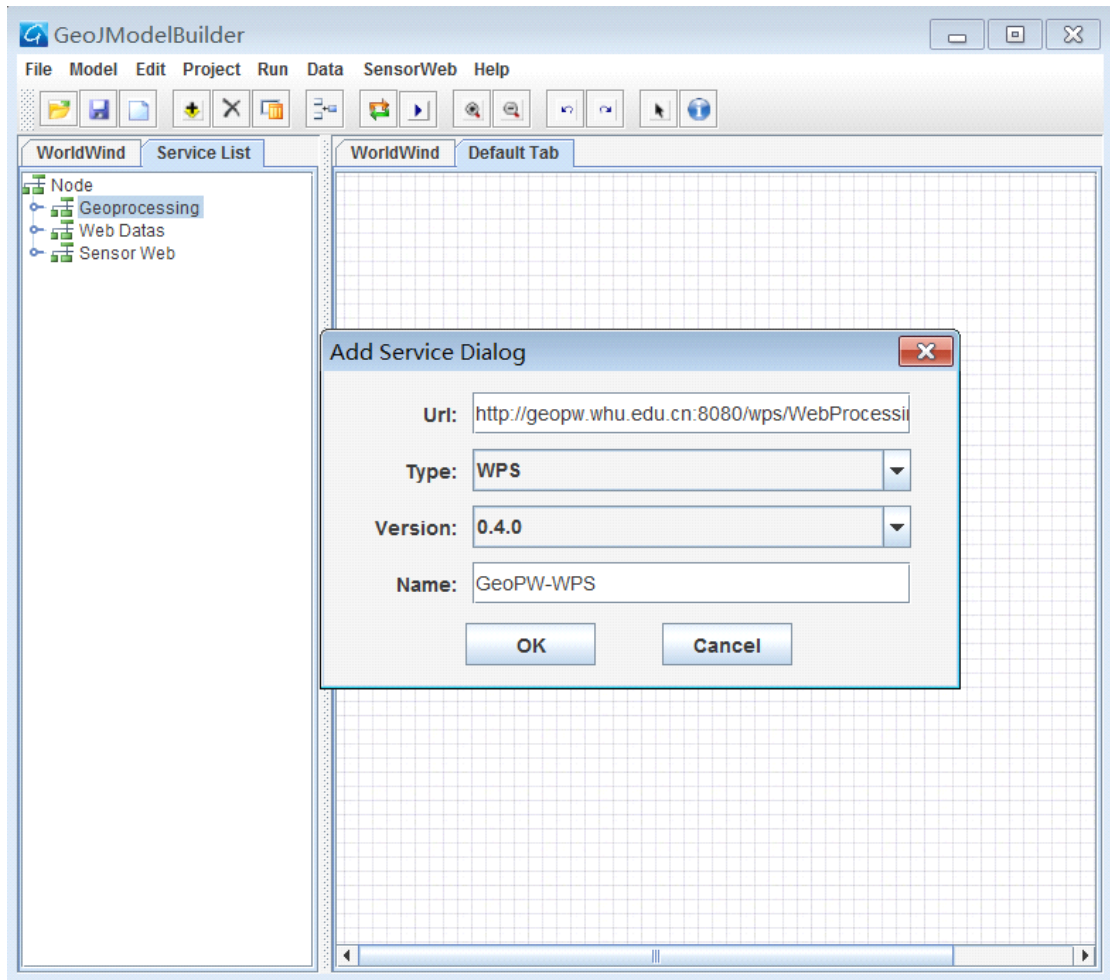


(19) Add Data: “Data ---> Add Data”, users can add data from local or web to the World Wind.

### 4.3 Service Management

#### (1) Add WPS Service

Right click on the “GeoProcessing” node and choose “add” button, then a WPS service dialog will pop up. See Fig.4.9.



**Fig. 4.9** Add a WPS

URL: The request address of GetCapabilities operation. For this case, it is <http://geopw.whu.edu.cn:8080/wps/WebProcessingService> .

There are more than 100 geoprocessing services provided by GeoPW which follows OGC WPS specifications. Refer to <http://geopw.whu.edu.cn/guide.html> for further information about GeoPW.

Type: The service type. It is WPS by default.

Version: The service version. Currently version 0.4.0 is supported.

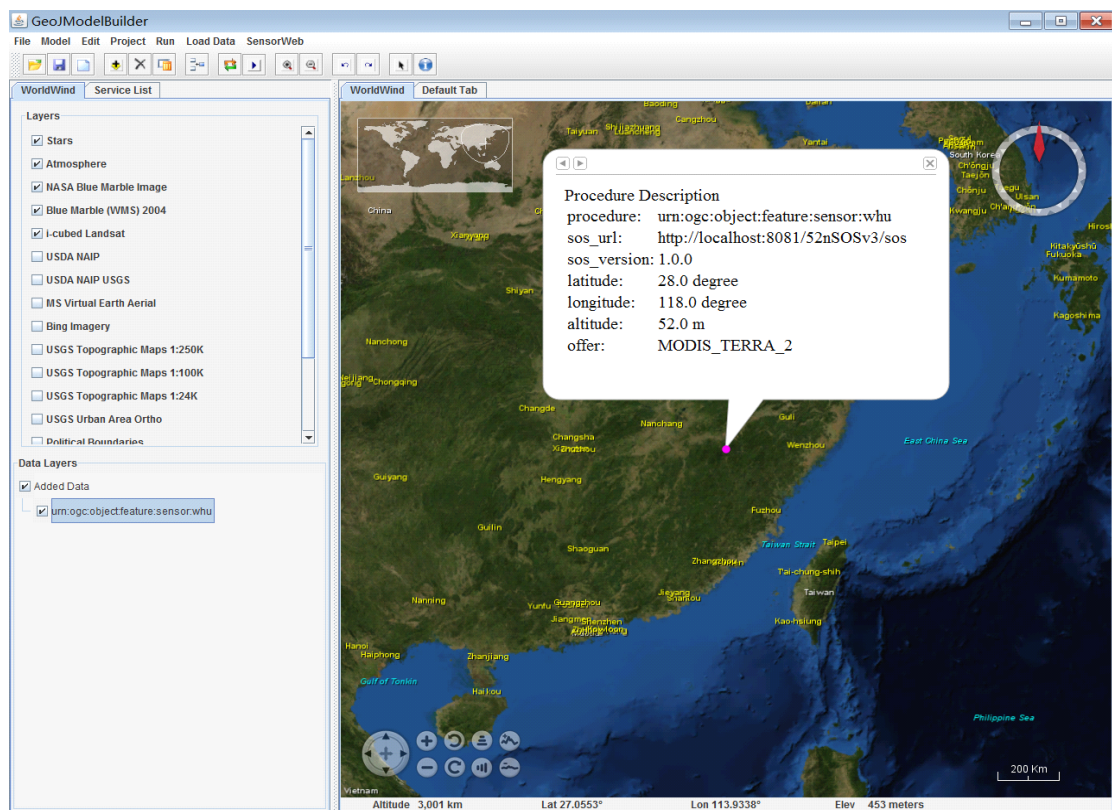
Name: The name of service. Here it is “GeoPW-WPS”.

## (2) Add Web Data

Right click on “Web Datas” and select “add” button, input the WFS address, and then the WFS data is loaded on the service list.

## (3) Add Sensor Web resources

Right click on “Sensor Web” and select “add” button. After the procedures in the SOS are added to the service list, user can view the sensor on the World Wind by right clicking on the sensor and choosing “show”.



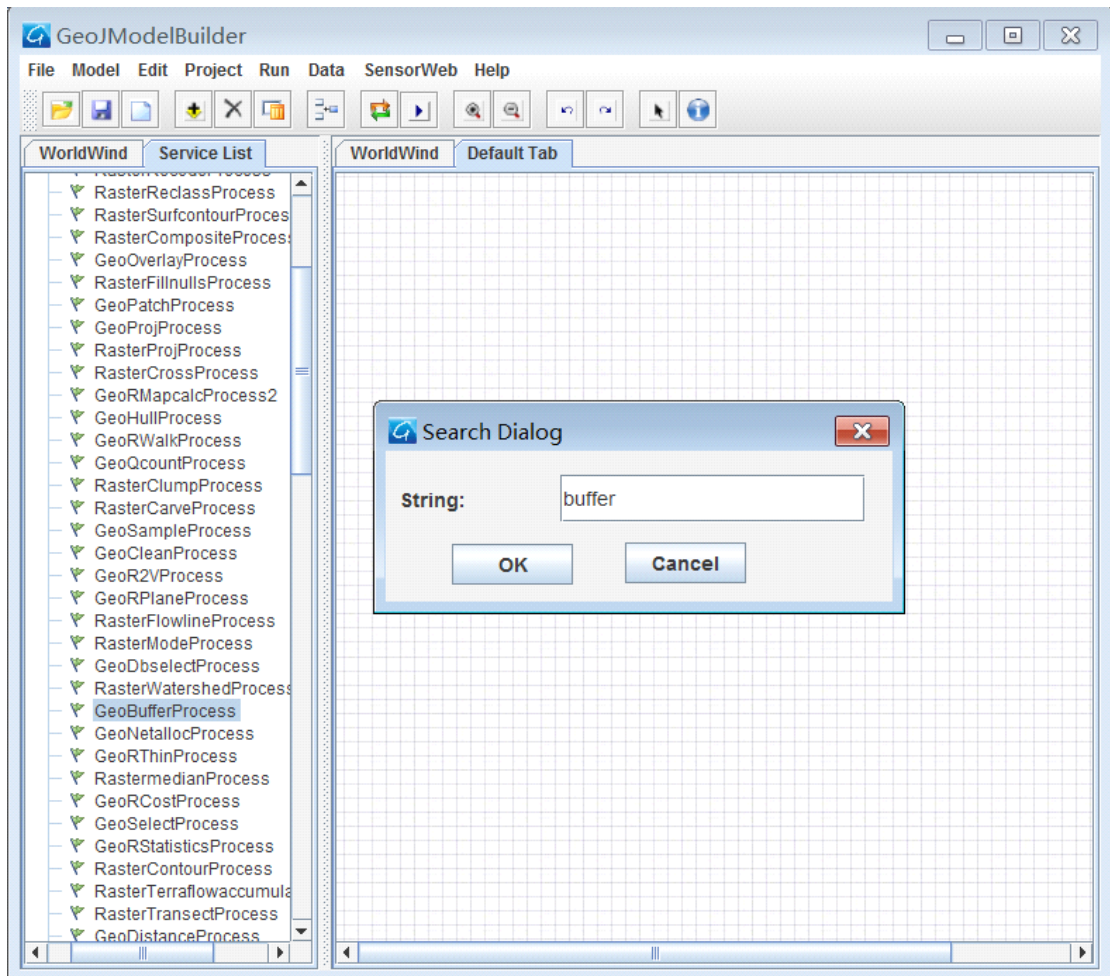
**Fig. 4.10** Show sensor on the World Wind

## (4) Delete Service

Right click on a selected service then delete it.

## (5) Find Services

Right click on the service list, and select “search” button, it will pop up a Search Dialog shown in Fig.4.11. KMP algorithm is adopted to search the services.



**Fig. 4.11** Search services

#### (6) Update Services

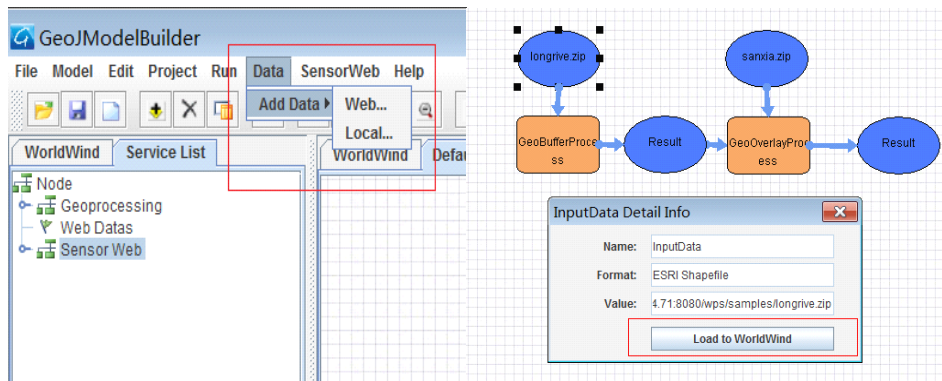
Users can update the services by update operation.

### 4.4 Data Management

#### 4.4.1 Add Data

There are two ways to add the data to the World Wind (Fig. 4.12):

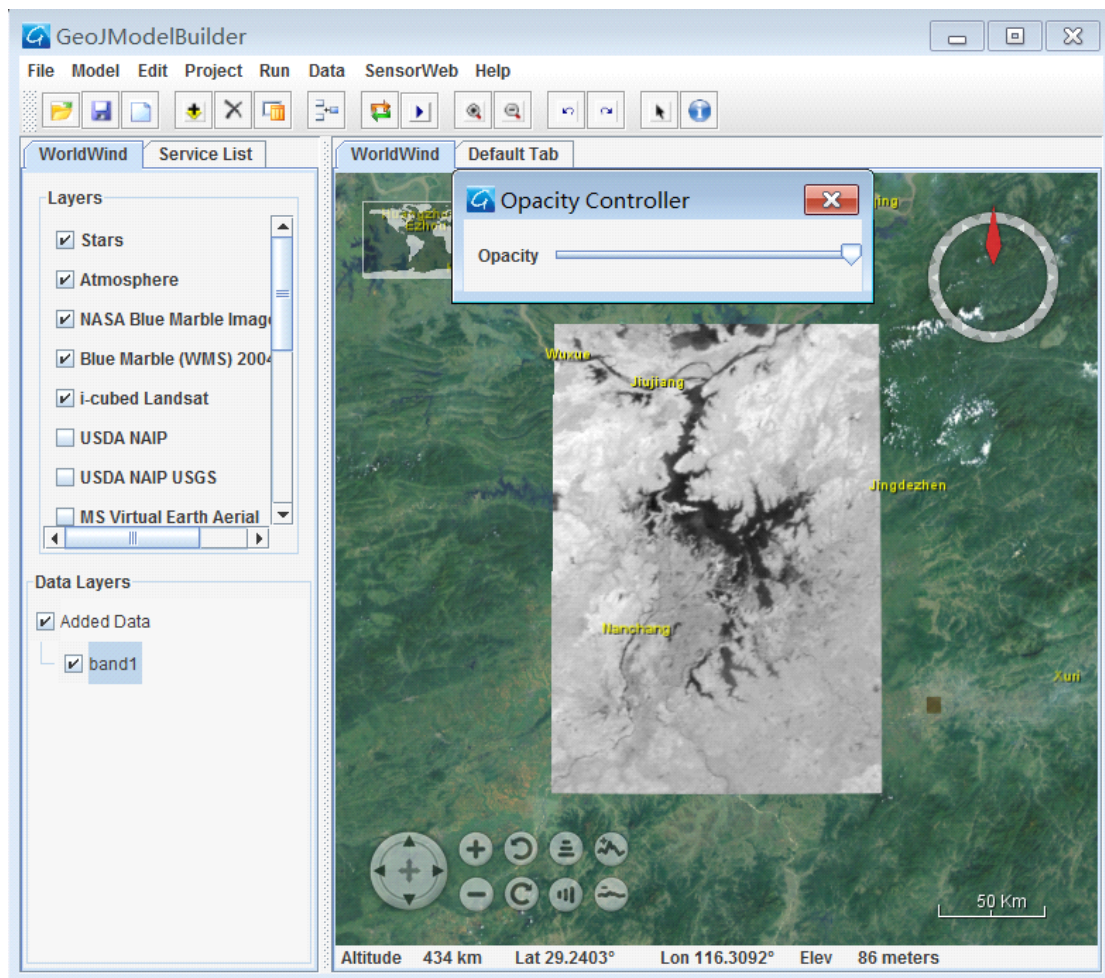
- (1) "Data" on the menu bar, select the source of data (Local or Web).
- (2) "Load" button in the Detail Information Dialog of the data model.



**Fig. 4.12** Add data

#### 4.4.2 Manage Data

Right click on the added data in the data layers, you can delete, rename and change the opacity of the data layer. And by clicking the provenance button, we can view the workflow from which the data is loaded in.



**Fig. 4.13** Data management



## 4.5 Geoprocessing workflow management

In this part, water area extraction example is used to demonstrate the life cycle of the workflow.

We use some past MODIS images as our data. Band 1 and 2 of each image go through the Normalized Difference Vegetation Index (NDVI) calculation, binarization, and rendering processes to derive the coverage of the water in certain area.

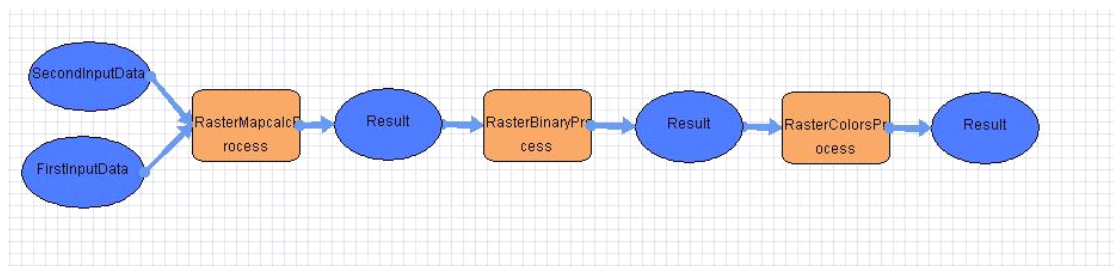
### 4.5.1 Life cycle of workflow

Users can work with geoprocessing workflows as following steps.

#### (1) Create a workflow

A workflow can be characterized by atomic models and control flow relationships. The atomic models can be created by dragging and dropping various geospatial services visually.

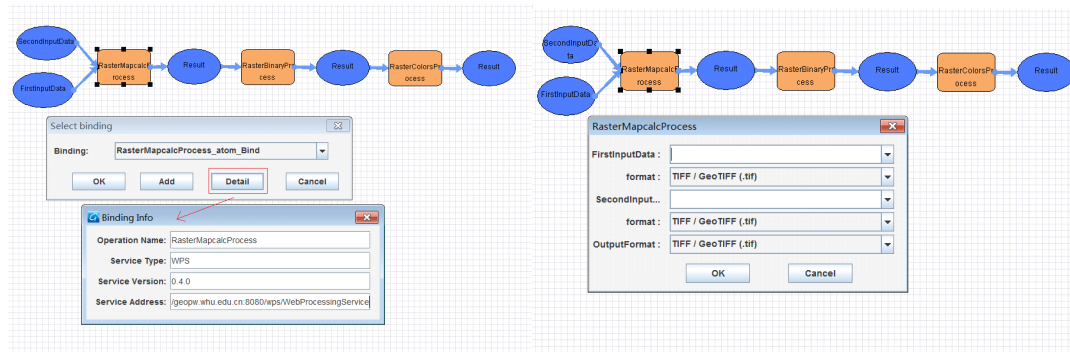
Drag the RasterMapCalcProcess , RasterBinaryProcess, and RasterColorsProcess from the service list into the workspace, and connect them with control flows.



**Fig. 4.14** Water area extraction workflow

#### (2) Binding services and data

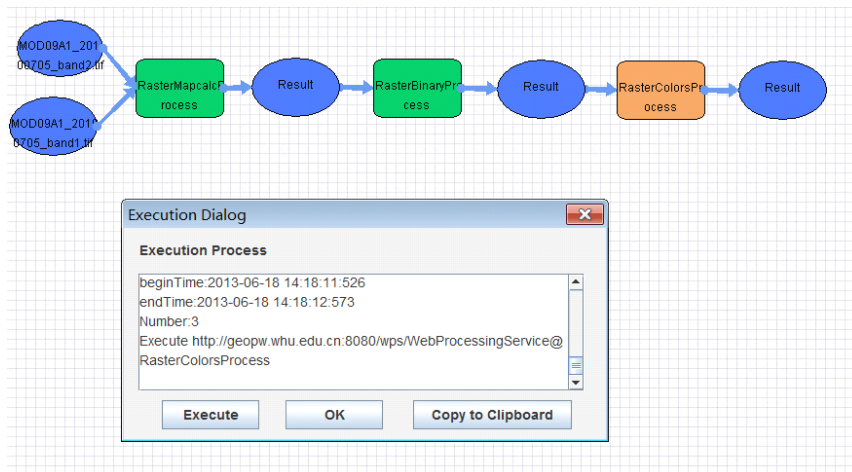
When created by dragging services, the atomic models have bound to the services by default. But alternative services can be bound instead of the default. Input arguments should be finished, too. This supports reusing the workflow by binding deferent services or data before it is executed.



**Fig. 4.15** Binding services and data

### (3) Workflow execution

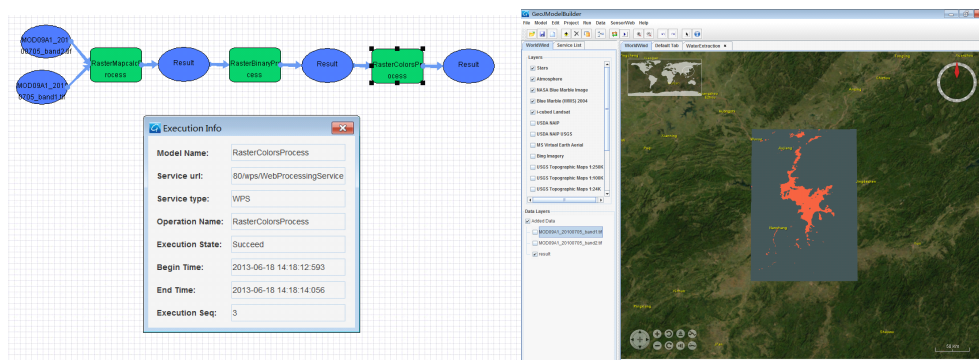
A workflow execution engine is implemented to execute the workflow, monitor the status and record the provenance.



**Fig. 4.16** Workflow execution

### (4) View results

This tool allows users to view the detail execution information and result data on World Wind.



**Fig. 4.17** View results

#### 4.5.2 Interaction with Workflows in Virtual Globe

The geoprocessing workflow will interact with World Wind during its whole life cycle. Input data of the workflow can come from the data layer of World Wind. The results including the intermediate results during and after the execution of workflow could be visualized on the World Wind. At the same time, users can locate the input data in the workflows by checking the provenance of the data layer on the World Wind.

##### (1) Data layer as input data

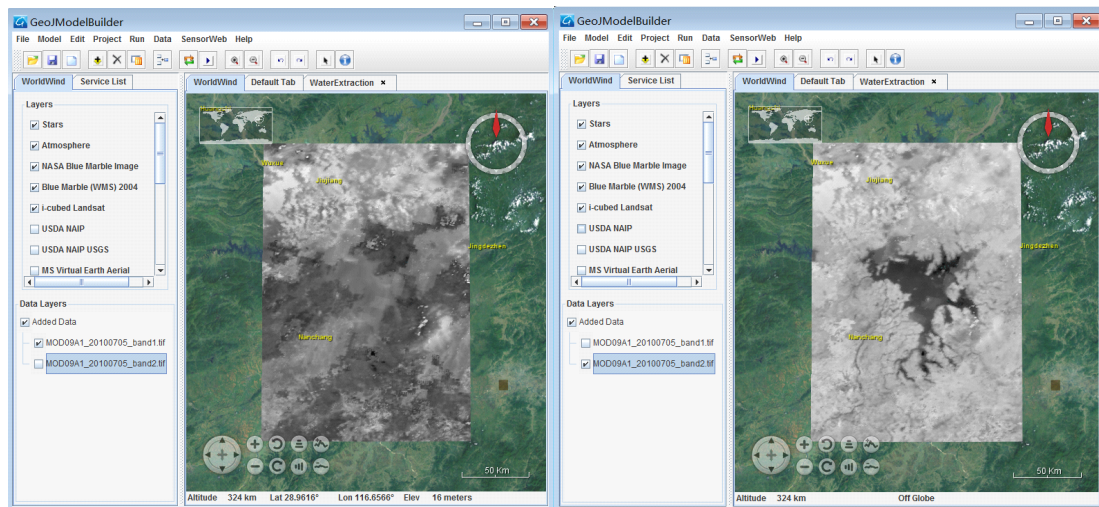
We add the Band1 and Band2 images to the World Wind.

Band1:

[http://geopw.whu.edu.cn:8099/FileStore/datas/MOD09A1\\_20100705\\_band1.tif](http://geopw.whu.edu.cn:8099/FileStore/datas/MOD09A1_20100705_band1.tif)

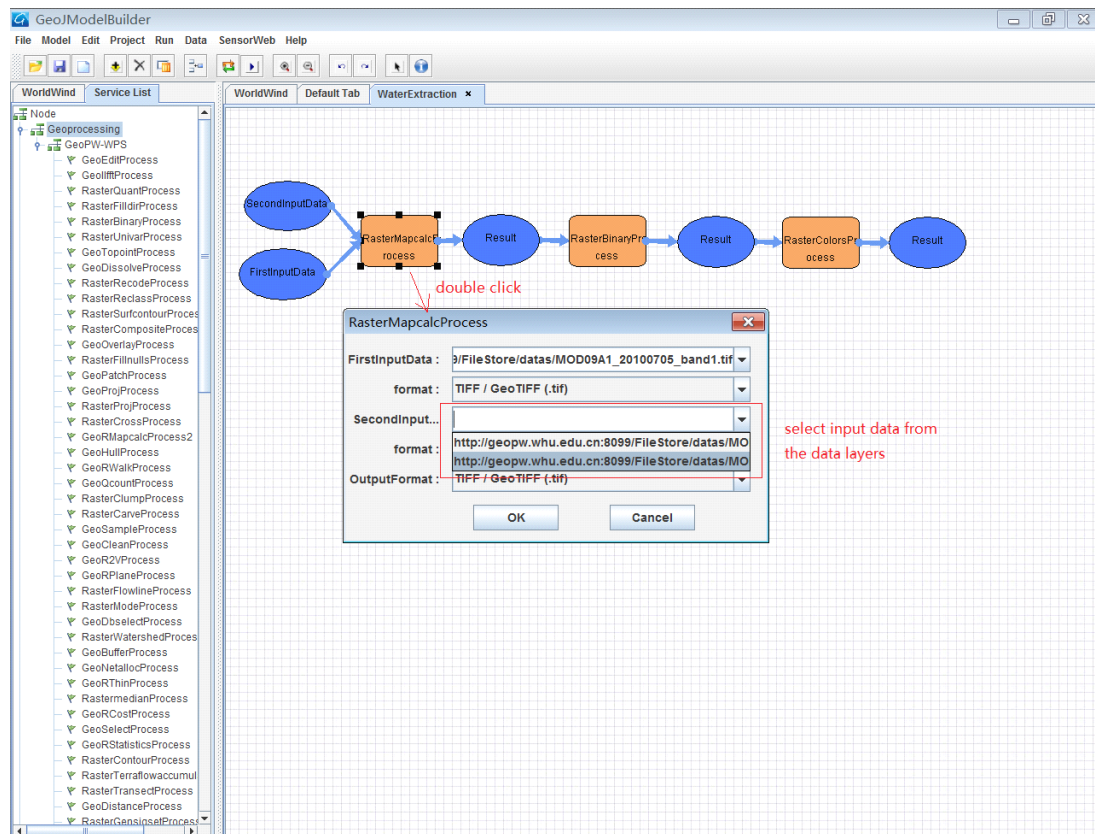
Band2:

[http://geopw.whu.edu.cn:8099/FileStore/datas/MOD09A1\\_20100705\\_band2.tif](http://geopw.whu.edu.cn:8099/FileStore/datas/MOD09A1_20100705_band2.tif)



**Fig. 4.18** Images on World Wind

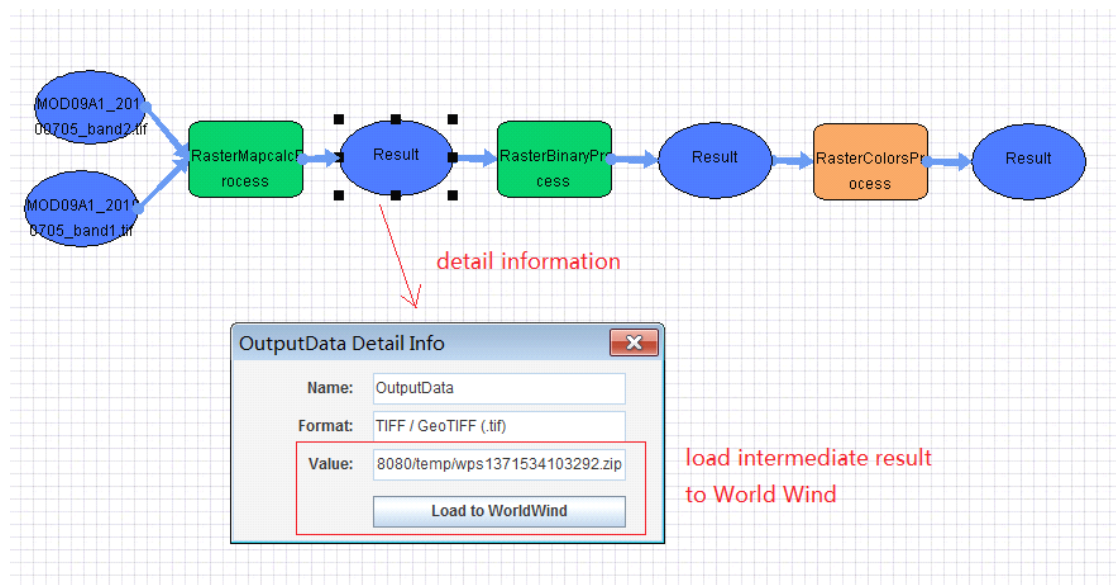
When assigning the parameters, the input data of the workflow can come from the data layers on the World Wind, see Fig.4.19.



**Fig. 4.19** Input data from data layers

## (2) View the results

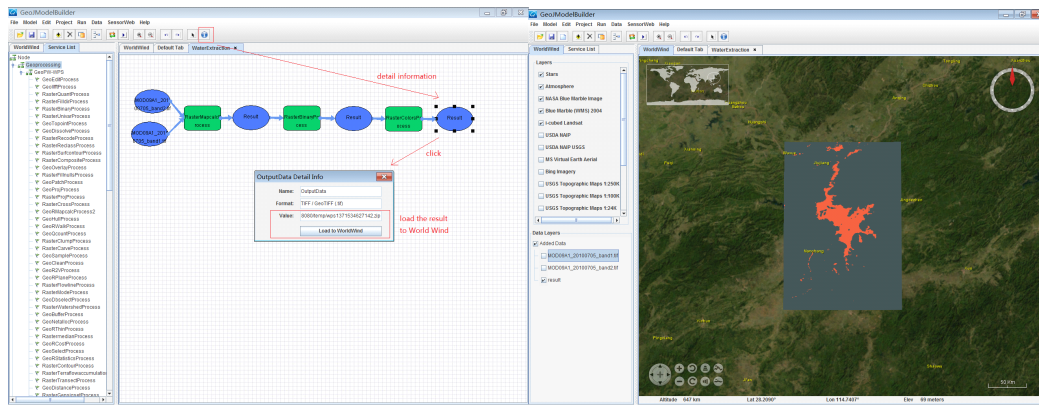
During the execution, users could view the intermediate results.



**Fig. 4.20** View the intermediate result

When finished, user can view the final result of the workflow.

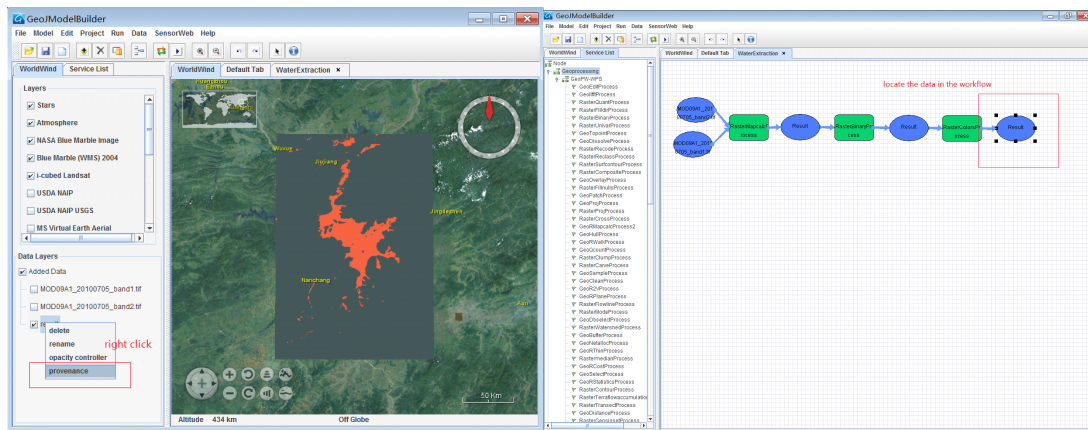




**Fig. 4.21** View the results

### 4.5.3 Provenance

Users could check the provenance of data easily.

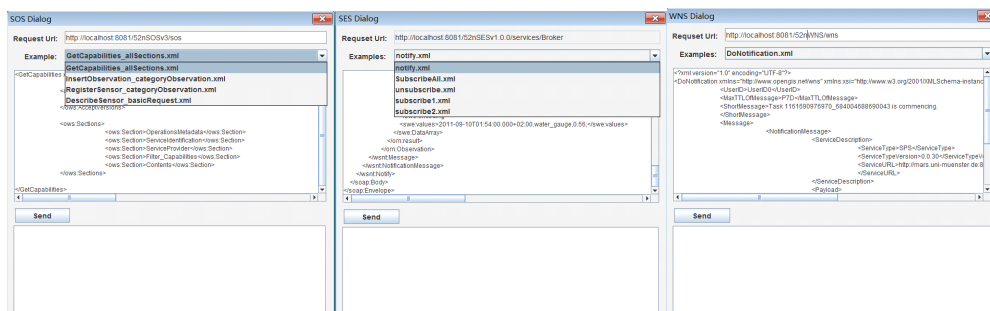


**Fig. 4.22** Provenance

## 4.6 Enviromental Monitoring

### 4.6.1 Sensor Web Client

The GeoJModelBuilder provides simple SOS/SES/WNS client.



**Fig.4.23** SOS/SES/WNS Clients

## 4.6.2 Subscription Client

The Subscription Dialog window is divided into three main sections, each with a red border and a numbered label in the top-left corner:

- Part 1:** Contains fields for SOS URL (http://localhost:8081/52nSOSv3/sos), Offer (GAUGE\_HEIGHT), Procedure (urn:ogc:object:feature:Sensor:IFGI:ifgi-sensor-1), and Property (urn:ogc:def:phenomenon:OGC:1.0.30:waterlevel). A Parse button is next to the SOS URL field.
- Part 2:** Contains fields for WNS URL (http://localhost:8081/52nWNS/wns) and WNS User (3 lei 812203488@qq.com). A Parse button is next to the WNS URL field.
- Part 3:** Contains fields for SES URL (http://localhost:8081/52nSESV1.0.0/services/Broker) and SES (SubscribeAll.xml). Below these is a large text area containing an XML document. At the bottom of this section is a Get Subscription ID button.

At the bottom of the dialog are two buttons: Subscribe and Cancel.

```
<?xml version="1.0" encoding="UTF-8"?>
<soap:Envelope xmlns:soap="http://www.w3.org/2003/05/soap-envelope" xmlns:w
<soap:Header>
  <wsa:To>http://localhost:8080/52nSESV1.0.0/services/Broker</wsa:To>
  <wsa:Action>http://docs.oasis-open.org/wsn/bw-2/NotificationProducer/Subsc
  <wsa:MessageID>uuid:4e595160-185a-9b3c-3eb6-592c7c5b0c7a</wsa:Mes
  <wsa:From>
  <wsa:Address>http://www.w3.org/2005/08/addressing/role/anonymous</ws
  </wsa:From>
</soap:Header>
<soap:Body>
  <wsnt:Subscribe>
    <wsnt:ConsumerReference>
      <wsa:Address>http://localhost:8080/MySESWnsFe
    </wsa:Address>
    </wsnt:ConsumerReference>
  </wsnt:Subscribe>
</soap:Body>
</soap:Envelope>
```

**Fig.4.24** Subscription dialog

The subscription operation can be divided into 3 parts.

Part 1: Choose the sensor to monitor, including the SOS address, offering and observedProperty.

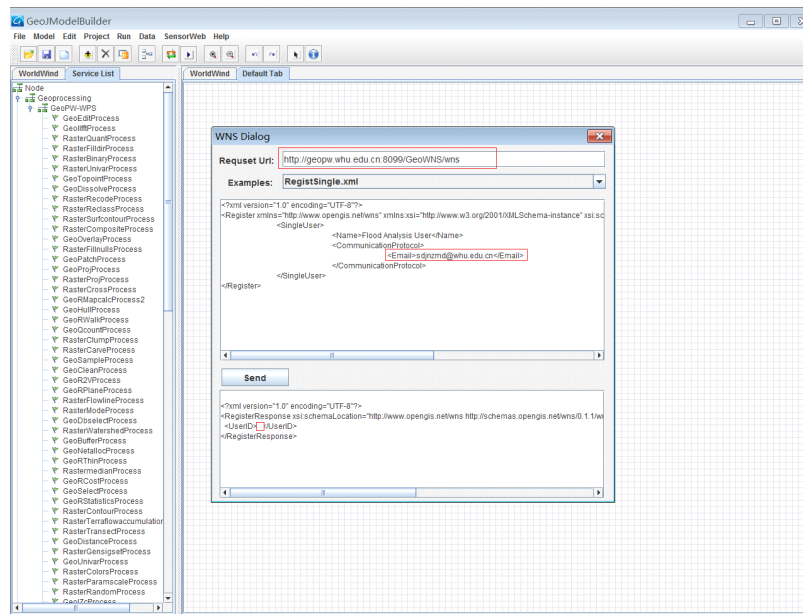
Part 2: Input the WNS user's email to receive the notification.

Part 3: Subscribe to the SES. Or you can just input the Subscription ID if somebody has already subscribed.

The information you put in the dialog will be sent to a broker, and the process is shown in Fig. 2.2

### 4.6.3 Example

- (1) Register a WNS user. Take sdjnzmd@whu.edu.cn for instance.



**Fig. 4.25** Register a WNS user

- (2) Register a sensor to the SOS.

Offering: MODIS\_TERRA\_2

Procedure: urn:ogc:object:feature:sensor:whu

ObservedProperty: urn:ogc:phenomenon:Band1, urn:ogc:phenomenon:Band2

```
<?xml version="1.0" encoding="UTF-8"?>
<smil:SensorML xmlns:smil="http://www.opengis.net/smil/1.1" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.w3.org/2001/XMLSchema-instance http://www.w3.org/2001/XMLSchema-instance">
  <smil:member>
    <smil:System>
      <!-- smil:identification element must contain the ID of the sensor -->
      <smil:identification>
        <smil:IdentifierList>
          <smil:identifier>
            <smil:term definition="urn:ogc:identifier:OGC:uniqueID">
              <smil:value>urn:ogc:object:feature:sensor:whu</smil:value>
            </smil:term>
          </smil:IdentifierList>
        </smil:identification>

        <!-- smil:capabilities element has to contain status and mobility information -->
        <smil:capabilities>

          <!-- last measured position of sensor -->
          <smil:position name="sensorPosition">

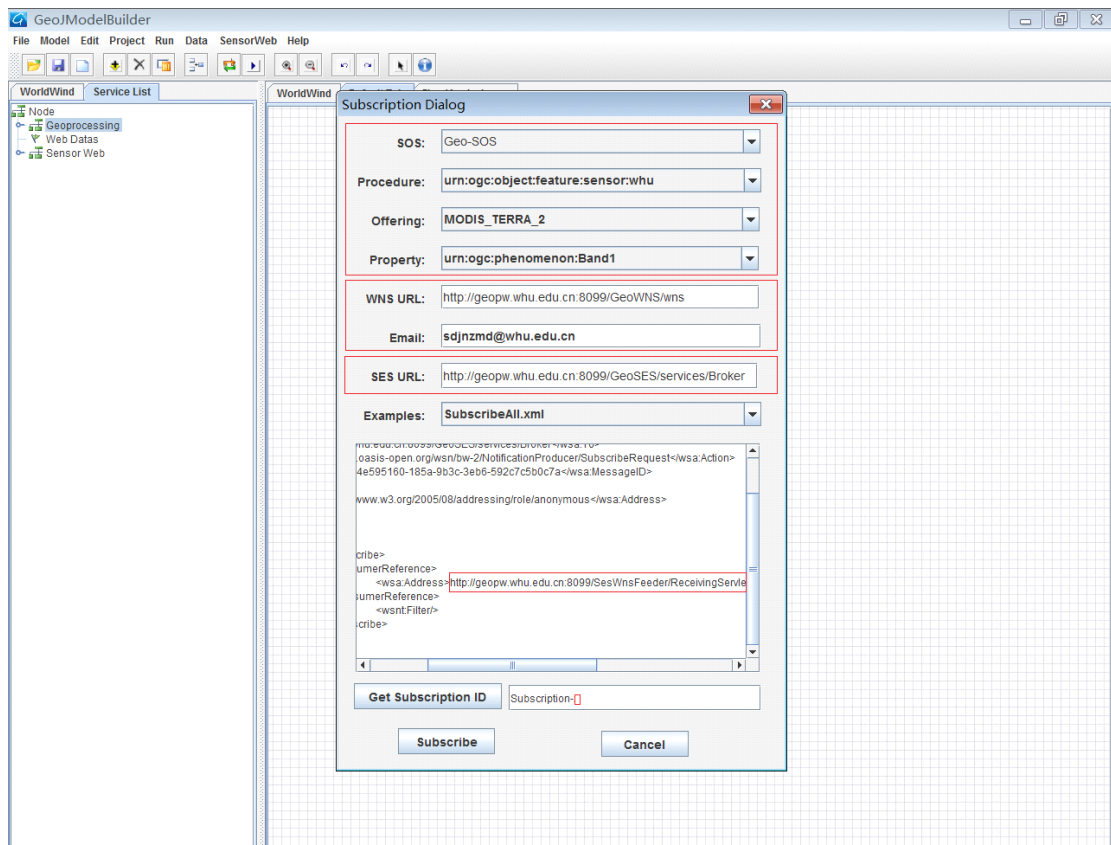
          <!-- list containing the input phenomena for this sensor system -->
          <smil:inputs>

          <!-- list containing the output phenomena of this sensor system; ATTENTION: these phenomena are parsed and inserted into the database: they have to contain
          offering elements to determine the correct offering for the sensors and measured phenomena -->
          <smil:outputs>
            <smil:OutputList>
              <smil:output name="text">
                <smil:Text definition="urn:ogc:phenomenon:Band1">
                  <smil:metaDataProperty>
                    <offering>
                      <id>MODIS_TERRA_2</id>
                      <name>band1 from modis</name>
                    </offering>
                  </smil:metaDataProperty>
                </smil:Text>
              </smil:output>
              <smil:output name="text">
                <smil:Text definition="urn:ogc:phenomenon:Band2">
                  <smil:metaDataProperty>
                    <offering>
                      <id>MODIS_TERRA_2</id>
                      <name>band2 from modis</name>
                    </offering>
                  </smil:metaDataProperty>
                </smil:Text>
              </smil:output>
            </smil:OutputList>
          </smil:outputs>
        </smil:System>
      </smil:member>
    </smil:SensorML>
```

**Fig. 4.26** Register a sensor

(3) Subscribe.

Notice that when you subscribe to the SES, you should input the <http://geopw.whu.edu.cn:8099/SesWnsFeeder/ReceivingServlet> as consumer address. If you have already subscribed, you can just input the subscription id without executing the “Get Subscription ID” operation.



**Fig. 4.27** Subscription

(4) Then when inserting observation to the SOS, WNS user will get the notification.



```
"http://www.opengis.net/swe/1.0.1" xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:xsi="
"http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/sos/1.0
http://schemas.opengis.net/sos/1.0.0/sosInsert.xsd
http://www.opengis.net/sampling/1.0
http://schemas.opengis.net/sampling/1.0.0/sampling.xsd
http://www.opengis.net/om/1.0
http://schemas.opengis.net/om/1.0.0/extensions/observationSpecialization_override.xsd" service="SOS"
version="1.0.0">
  <AssignedSensorId>urn:ogc:object:feature:sensor:whu</AssignedSensorId>
  <om:CategoryObservation>
    <om:samplingTime>
      <gml:TimeInstant>
        <gml:timePosition>2010-07-13T23:44:15.000+08:00</gml:timePosition>
      </gml:TimeInstant>
    </om:samplingTime>
    <om:procedure xlink:href="urn:ogc:object:feature:sensor:whu"/>
    <om:observedProperty xlink:href="urn:ogc:phenomenon:Band1"/>
    <om:featureOfInterest>
      <!-- a sampling feature is needed to insert CategoryObservations -->
      <sa:SamplingPoint gml:id="whu_1">
        <gml:name>PADER</gml:name>
        <sa:sampledFeature xlink:href=""/>
        <sa:position>
          <gml:Point>
            <gml:pos srsName="urn:ogc:def:crs:EPSG:4326">116 28</gml:pos>
          </gml:Point>
        </sa:position>
      </sa:SamplingPoint>
    </om:featureOfInterest>
    <om:result>http://geopw.whu.edu.cn:8099/FileStore/datas/MOD09A1_20100713_band1.tif</om:result>
  </om:CategoryObservation>
</InsertObservation>
```

Fig. 4.28 Insert observation

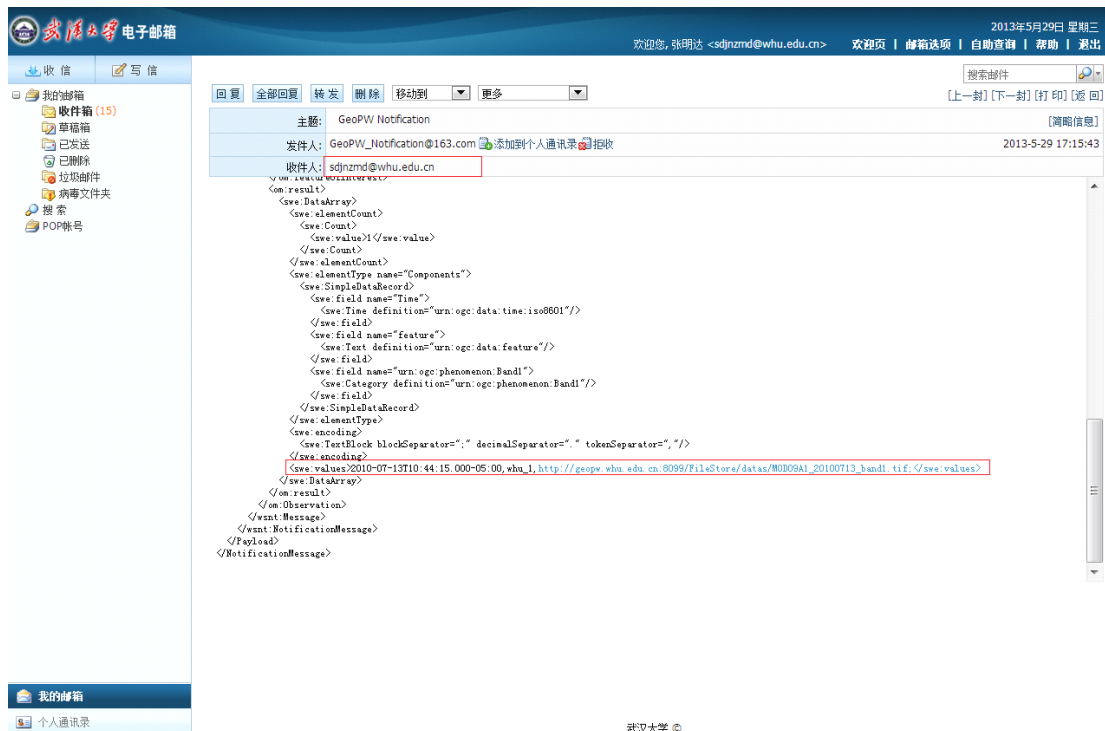


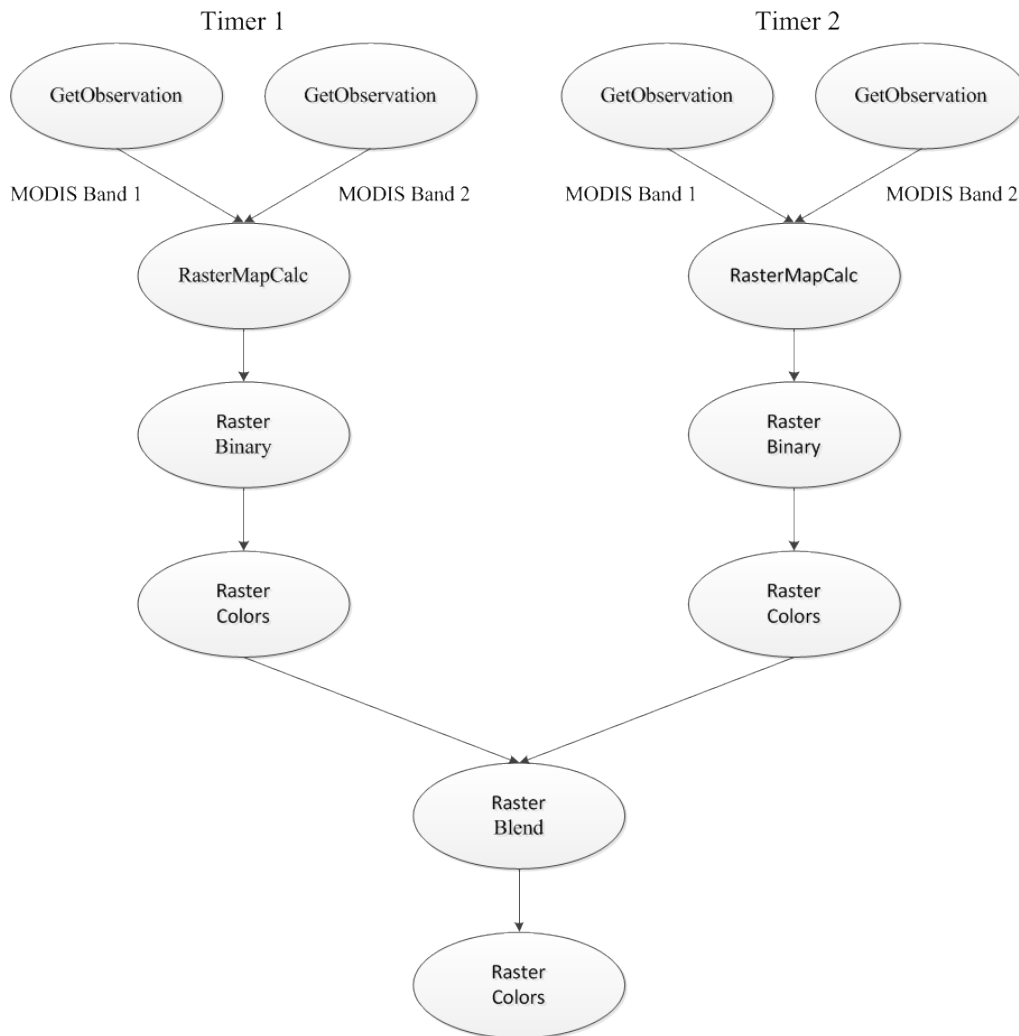
Fig. 4.29 Notification

## 5. Flood Analysis Case

This tool can be commonly used in geospatial data analysis and environmental monitoring. Here is flood analysis case to demonstrate how to use it.

In this case, we use past MODIS images as our data. Band 1 and 2 of each image go through the Normalized Difference Vegetation Index (NDVI) calculation, binarization, and rendering processes to derive the coverage of the flood for each period. The two images of different periods are mixed using blending process to generate a thematic flood image that reflects the changes in the water coverage area.

The scientific model is show in Fig.5.1.



**Fig. 5.1** Scientific model of flood analysis

### 5.1 Preparation

a) Register sensor to SOS and insert observation.

Offering: MODIS\_TERRA\_2

Procedure: urn:ogc:object:feature:sensor:whu

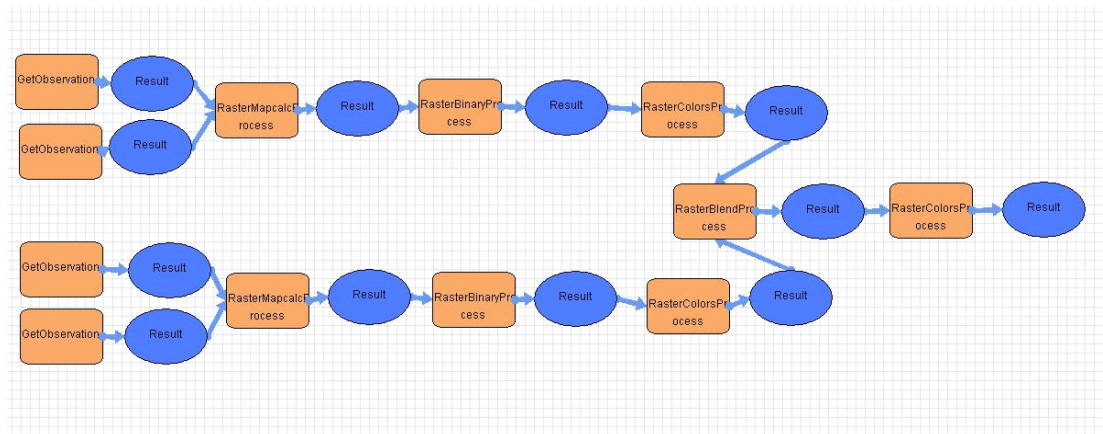
ObservedProperty: urn:ogc:phenomenon:Band1, urn:ogc:phenomenon:Band2

See Part 4.6.3.

b) Subscription. See Part 4.6.3.

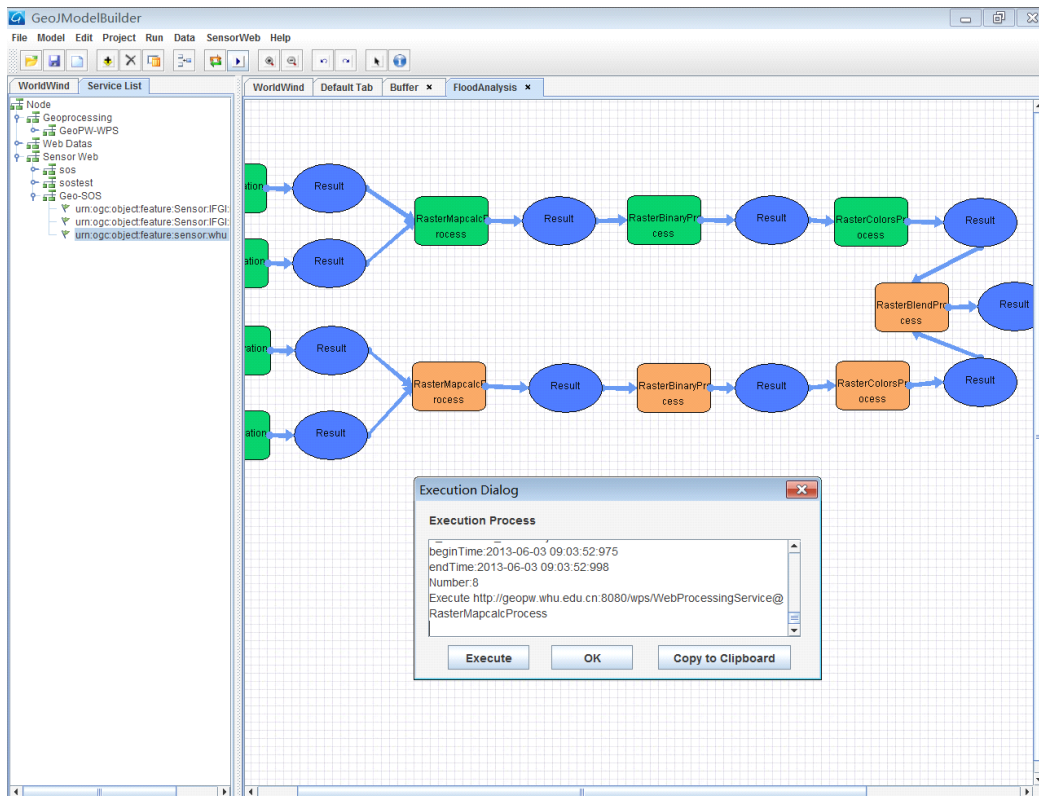
## 5.2 Create Workflow

Drag the sensor “urn:ogc:object:feature:sensor:whu” from the Sensor Web list into workspace as the data source. Then search the required services from the service list and drag them to the workspace. At last, a flood analysis workflow is generated .



**Fig. 5.2** Flood analysis workflow

## 5.3 Execute the Workflow

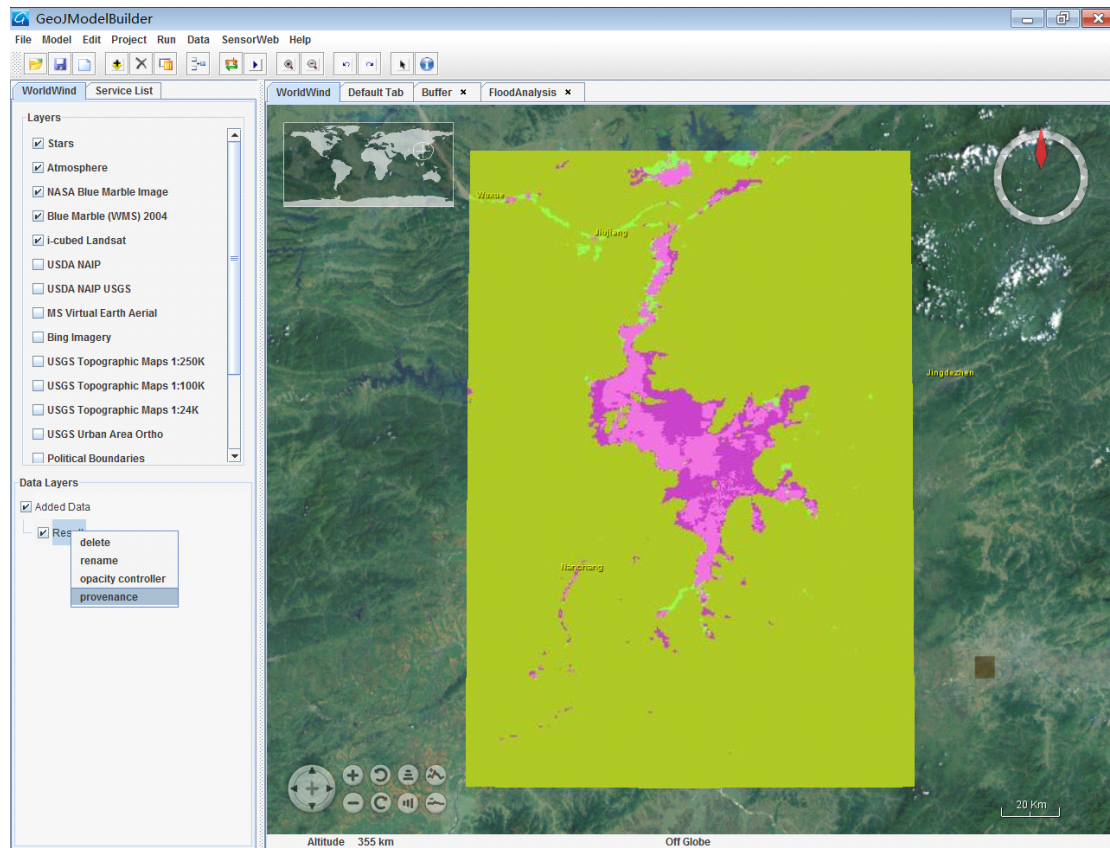


**Fig. 5.3** Execute the flood analysis workflow

The green suggests a successful execution. And the status information of the execution can be viewed in the Execution Dialog.

## 5.4 Display on the World Wind

The result can be added to the World Wind. Also, you can return to the workflow by right clicking on the Result layer and selecting provenance button. See Fig.5.4.



**Fig. 5.4** Result on the World Wind